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# Lubrication

A Technical Publication Devoted to  
the Selection and Use of Lubricants

*This Issue*



STATIONARY  
TURBO  
GENERATORS



PUBLISHED BY  
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# LUBRICATION

A TECHNICAL PUBLICATION DEVOTED TO THE SELECTION AND USE OF LUBRICANTS

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## STATIONARY TURBO GENERATORS

THE demand for energy throughout the world continues to increase at an accelerated rate.

As an example, in the United States, over one-half of all the coal ever consumed was burned since 1920 and approximately one-half of all the oil and gas ever consumed has been burned since 1940. In 1920 wood supplied 85 per cent of Russia's total energy requirements.

The electrical industry in a little more than 60 years has developed into a prominent factor in supplying our ever-increasing energy needs. The industry has reached such stature that man's ability to use electric power is considered an indication of the level of civilization that he has attained. To continually improve his standard of living, large additional amounts of electrical power to do his work more efficiently will be necessary.

To meet the accelerating demand for electrical power the industry has not only installed additional capacity but has made major advances in the more efficient use of energy. Total production of electrical energy in the United States has increased at an annual rate of 7.38 per cent for the last four years and during the same four-year period the per capita usage increased 24 per cent. The growth of the electrical industry in the United States has increased two and one-half times as fast as the increase in gross national product. While the total production of electrical power in this country (724 billion kilowatt hours in 1958), was more than three times the amount generated by the next largest producer, the percentage rates of increase in many countries

throughout the world are considerably higher. Based only on today's established needs, and discounting the possibility of new uses, it is anticipated that electric power requirements in the United States alone will increase to 2000 billion kilowatt hours in 1975.

While the new atomic power plants<sup>1</sup> are the most publicized increases in generating capacity, their output compared to the total power generated remains at the moment relatively small. It has been estimated that it will be five years before atomic power can commercially compete with power from conventional sources and it will be twenty years before energy from nuclear fission becomes a sizable factor in the production of electricity.

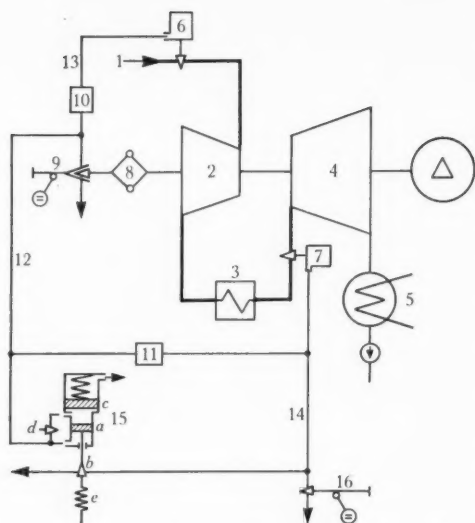
### EQUIPMENT TYPES

The majority of the large stationary plants producing electricity commercially employ steam or hydro-turbines to drive electric generators. Recently, gas turbines have also been developed as prime movers for electric generators. The similarity of their application and lubrication problems makes it feasible to include all three types in this discussion.

While a substantial portion of our electrical power requirements is generated by diesel-powered plants,<sup>2</sup> the lubrication requirements of their reciprocating engines differ considerably from turbine

<sup>1</sup>Lubrication, Sept. 1959 issue, "Nuclear Power Plants."

<sup>2</sup>Lubrication, May 1958, "Trends in Lubrication of Large Low-Speed Diesels."



Courtesy of Brown, Boveri & Company, Ltd.

Figure 1 — Typical reheat cycle (1) Live Steam, (2) High pressure turbine, (3) Reheater, (4) Low pressure turbine, (5) Condenser, (6) H.P. regulating valve with hydraulic servomotor, (7) Interceptor valve with hydraulic servomotor, (8) Governor, (9) Speed adjusting gear, (10) Leak-off amplifier for 6, (11) Relay for 7, (12) Control system of governor, (13) Control system of h.p. regulating valves, (14) Control system of interceptor valves, (15) Pressure-gradient relay a = Balance piston, b = Control port, c = Buffer piston, d = Variable throttle, e = Spring, (16) Starting valve for 7.

driven units and will not be repeated. Gas engines<sup>3</sup> are also used but are omitted for the same reasons.

In the steam turbine,<sup>4</sup> high pressure, high temperature steam expands through an elaborate system of turbine blades, converts the heat energy in steam to mechanical energy which drives the generator and produces electricity. The water wheel or runner in a hydro electric unit converts the kinetic energy

<sup>3</sup>Lubrication, July 1950, "Gas and Dual-Fuel Engine Lubrication."  
<sup>4</sup>Lubrication, June 1952, "Electric Power—Steam Turbine Lubrication."

of flowing water to mechanical energy which again drives the generator. The gas turbine<sup>5, 6</sup> drives the generator by converting the energy in hot combustion gases to mechanical energy. The hot gases are usually produced by burning fuel in a combustion chamber supplied with compressed air from the turbine compressor, however free-piston gasifiers<sup>5</sup> are also a possibility.

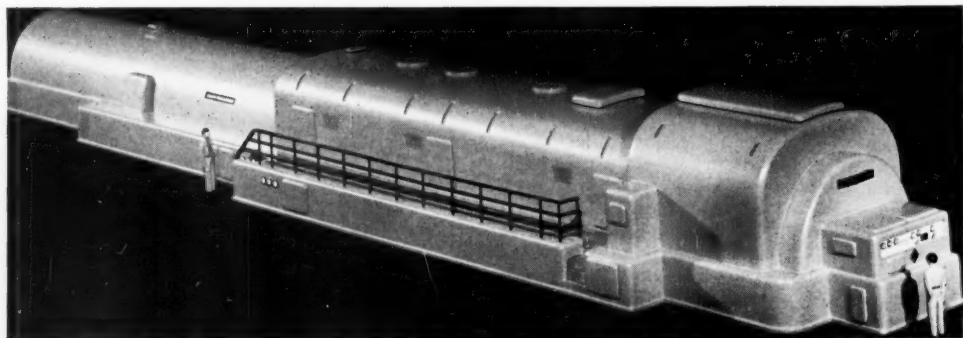
The type of equipment used to convert energy to electrical power is dependent upon many factors. Of the turbine type installations in the United States today approximately 80 per cent of the electrical power is generated by steam turbine plants while most of the remaining 20 per cent is generated by hydraulic turbines. However, in Canada and mountainous European countries, where water power is abundant, the hydro-electric plant is predominant. While atomic energy will become an increasingly larger source of electrical power, most of the immediate increases in large scale generating capacity will be steam or hydro-electric plants. In the United States the average increase in hydro-electric capacity is two to two and one-half million kilowatts per year with an undeveloped potential of 90 million kilowatts remaining.

Currently the use of gas turbines to generate electricity is very limited. However, in special applications where small plant size and a smaller initial investment are important factors, gas turbine generating equipment has been installed for standby equipment and to provide power at peak loads.

Perhaps the biggest future potential for the gas turbine in power generation is the gas turbine-steam turbine power plant which is being given serious engineering study. In such a plant, the gas turbine compressor furnishes compressed combustion air to the supercharged boiler while the gas turbine is driven by boiler flue gases. The steam generated in the boiler is used to drive a conventional steam turbine. If the boiler can be super-

<sup>5</sup>Lubrication, Sept. 1958, "Free Piston Engines."

<sup>6</sup>Lubrication, March 1959, "Aircraft Turbine Lubrication."



Courtesy of Allis-Chalmers Mfg. Co.

Figure 2 — Scale Model of outdoor tandem triple-flow steam turbine-generator unit with geared exciter.



*Courtesy of S.A. "Le Matériel Electrique S.W."*

Figure 3 — General view of hydro-electric plant during installation of a new unit.

charged to several atmospheres and the combustion gases expanded through the gas turbine at permissible temperatures, the gas turbine can then generate electrical power in addition to the steam turbine. It is estimated that this double cycle would improve plant efficiency by 4 to 8 percent.

### Recent Advances

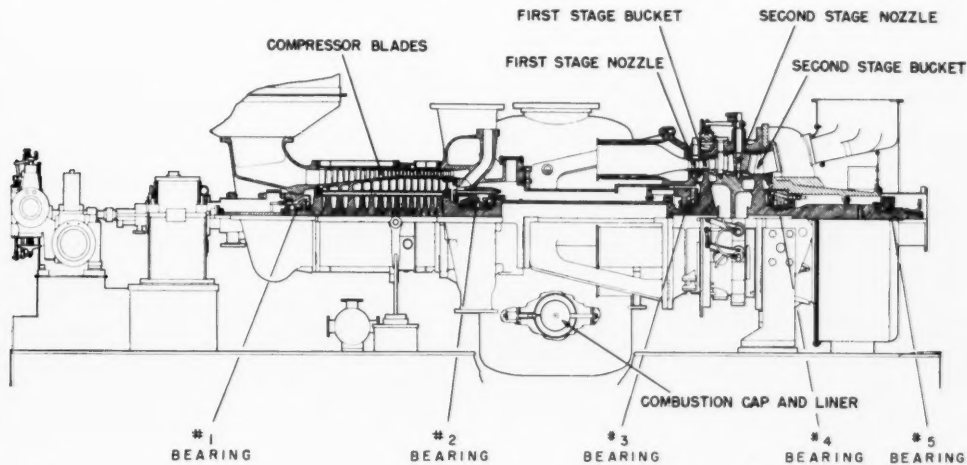
A review of the thermal performance of steam power plants will illustrate how technical advances in the more efficient use of heat energy helped the industry to meet the ever-increasing demand for

electrical energy. The first steam turbine plant in 1900 used 50,000 British Thermal Units of heat to generate one kilowatt hour of electricity. It wasn't until 1950 that any United States plant achieved an average heat rate below 10,000 British Thermal Units per kilowatt hour. Today the most efficient steam turbine plant has a heat rate of only 9,000 British Thermal Units per kilowatt hour.

These large increases in efficiency were made possible by the increases in unit size, higher steam temperatures and pressures, plus the use of reheat steam cycles. The average unit size of electric utility steam turbine units manufactured during the ten year period from 1948 to 1958 increased from 60 megawatts<sup>7</sup> to 150 megawatts. A 600 megawatt unit is presently under construction and several units over 300 megawatts are currently operating. Steam temperatures of 900°F were used in 1936, today 1200°F is anticipated. Similarly steam pressures have increased from 1100 psi in the 1930's to 5000 psi in units now under construction. The reheat cycle illustrated in Figure 1 began in the same period and progressed from a single reheat cycle having an initial temperature of 940°F and reheat temperature of 900°F to the double reheat cycle with operating temperatures of 1200°F, 1050°F and 1050°F. The space requirements of a steam turbine plant also reflect the improvement in efficiency: a World War I plant required 40 cubic feet per kilowatt while post World War II plants require only 25 cubic feet per kilowatt.

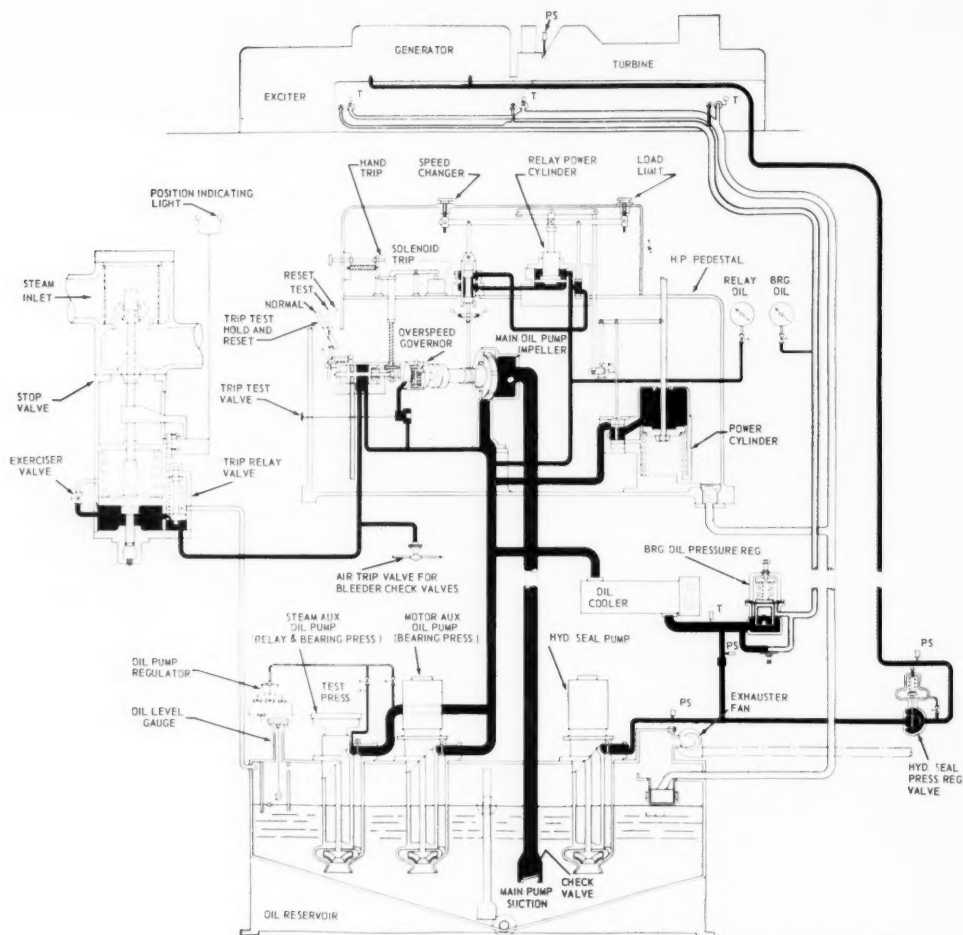
While not directly related to power plant efficiency, higher transmission, subtransmission and distribution voltages will also improve the over-all efficiency of furnishing power to the customers.

<sup>7</sup>One megawatt = 1,000,000 watts = 1000 kw.



*Courtesy of General Electric Co.*

Figure 4 — Partial section of gas turbine used to drive electric generator.



*Courtesy of Allis-Chalmers Mfg. Co.*

Figure 5 — Lubrication and governing system for steam turbine and generator with hydrogen seals.

Transmission voltages will probably increase from the present limit of 345 kilovolts to the range of 460 to 600 kilovolts.

It should be emphasized that the advances in power generation have not been limited solely to steam power plants, however, the very limited number of instances cited do serve to illustrate the progress made by the industry to meet the increasing demands for electricity. Hydro-electric plants, diesels, and the comparatively new gas turbine plants have also made valuable contributions toward improving the efficiency and dependability of electrical power generation.

The designers of modern generating equipment have been aware of the increasing demands the

larger, higher speed units operating at improved efficiencies and higher outputs have placed on the material suppliers. The improvements in efficiency and dependability of the power generating industry are dependent upon their successful cooperation with many individual component suppliers. While the cost of lubrication is an insignificant part of the operating expense of a power generating plant, the cooperative efforts of equipment designers and the oil manufacturers were required to keep the demands on the oil within the limits of its ability to perform satisfactorily and at the same time take full advantage of advances in petroleum technology as quickly as possible.

General views of steam, hydro and gas turbine equipment are shown in Figures 2, 3 and 4.



## LUBRICATION

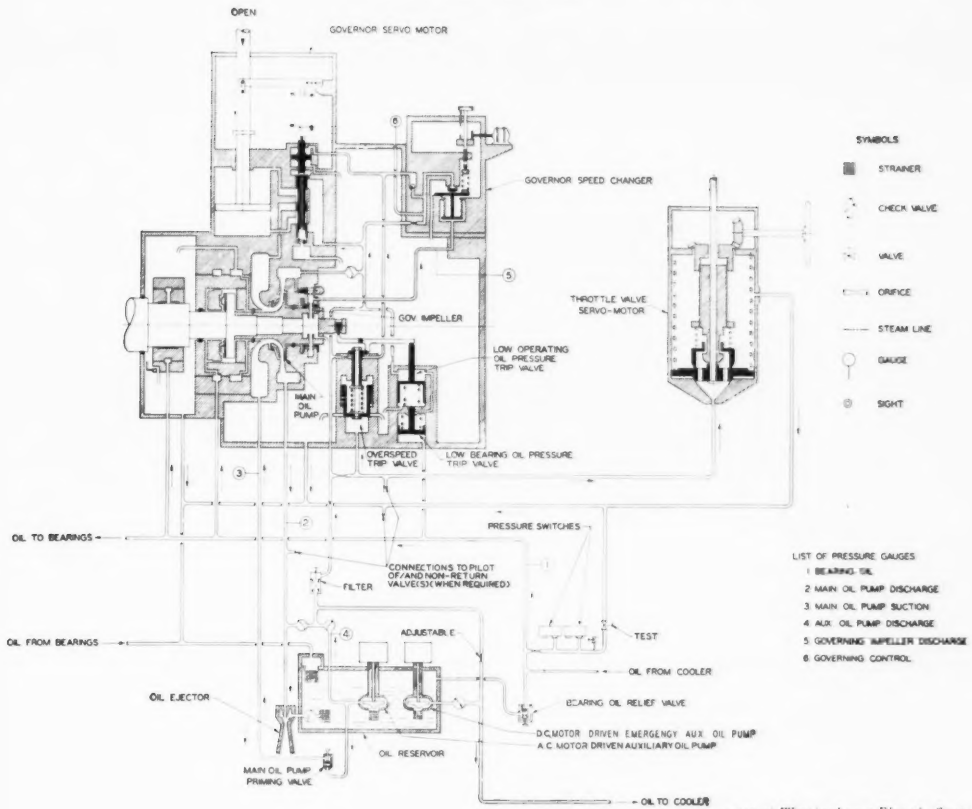
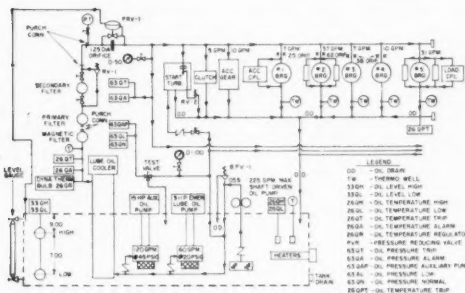


Figure 6 — Lubrication and governing system for a steam turbine.

## EQUIPMENT LUBRICATION

Examination of the lubricating systems of the steam, hydro and gas power plants illustrates the variety and yet similarity of the demands placed on the lubricating oil. Typical lubricating systems for steam and gas turbine plants are shown in Figures

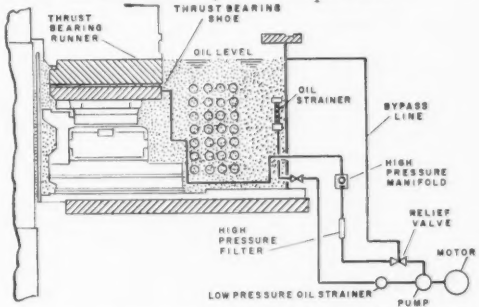


Courtesy of General Electric Co.

Figure 7 — Lubrication system for a gas turbine.

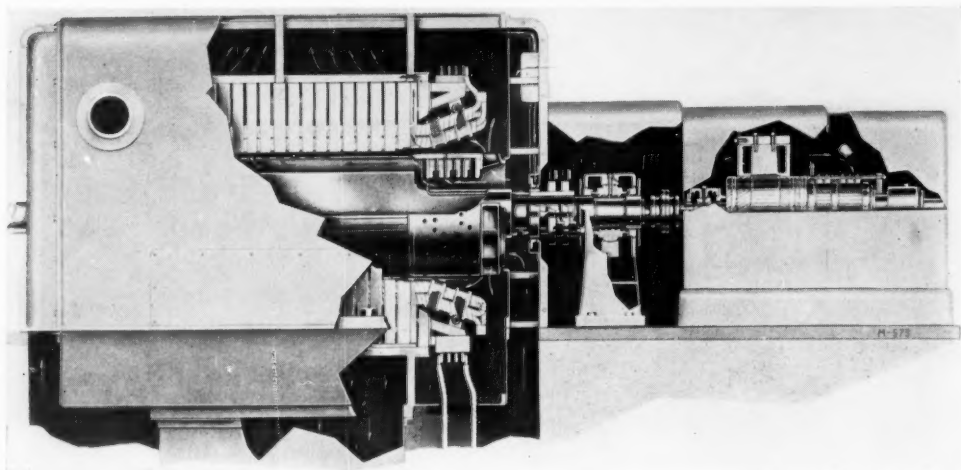
5 through 7. Figure 8 illustrates the high pressure oil system used to "float" the thrust bearing of a hydro-electric unit. Figures 9 and 10 are sectional views of a steam turbine and an alternating current generator with its exciter.

In every case the oil must perform the following functions to assure dependable operation.



Courtesy of Allis-Chalmers Mfg. Co.

Figure 8 — High pressure oil system for thrust bearing in hydro-electric unit.



*Courtesy of Worthington Corp.*

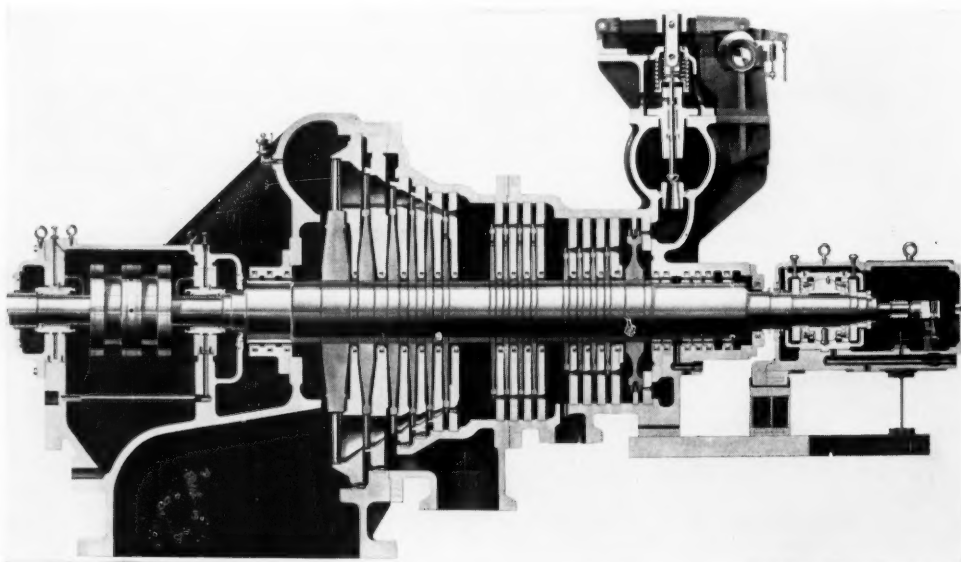
Figure 9 — Alternating current generator with its direct-current exciter.

1. Lubricate the bearings of the prime mover and the electrical generator.
2. Act as a cooling medium for the turbine bearings.
3. Lubricate the governor and control mechanisms.
4. Act as a hydraulic medium to transmit the governor-varied impulse to the control mechanism.

5. Act as a sealing medium to prevent loss of hydrogen from hydrogen-cooled generators.

6. Prevent the formation of rust and sludge within the confines of the lubricating system.

To meet the varied requirements in a power generating plant of lubricating, cooling and protecting from corrosion, the lubricant must have the following properties:



*Courtesy of Worthington Corp.*

Figure 10 — Sixteen stage condensing steam turbine.





*Courtesy of Westinghouse Electric Corp.*

Figure 11 — Eight and twenty-two inch spherically seated steam turbine bearings.

1. It must have the correct viscosity.
2. It must be stable, resisting oxidation and sludging during service and during extended storage periods.
3. It must prevent rusting of ferrous metal and be noncorrosive to turbine parts made from several other metals.
4. It must be resistant to foaming.
5. It must be able to free itself rapidly from air and water.
6. It must be clean initially and capable of being kept clean in service by the purifying system provided.

### Viscosity

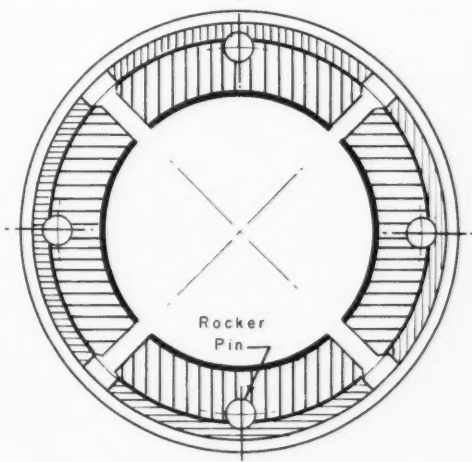
Inspection of the types of bearings used and the prescribed permissible operating temperatures for the steam, hydro and gas power plants illustrates the importance of oil viscosity. The temperature limits are established so the proper viscosity oil will satisfactorily lubricate the moving parts, act as a hydraulic medium in the governor system and still keep friction losses to a minimum in the bearings.

Figure 11 illustrates the variations in size of bearings that are encountered in steam turbines. By careful design the bearing loads in all three types of units are maintained at conservative levels

which range from 200 to 450 pounds per square inch. Provisions are also made to compensate for bearing misalignment when the turbine is running or during starting and stopping operations when large changes in temperatures are encountered. Most bearings in modern units are mounted in spherical seats and adjustments in alignment are achieved by the sliding of the spherical keys. In other applications a bending and/or twisting of the flexible support plate will reduce the misalignment. One manufacturer has recently developed a tilting pad journal bearing, Figure 12, which permits curved sections of the bearing to rock on pins in order to achieve alignment and reduce vibrations.

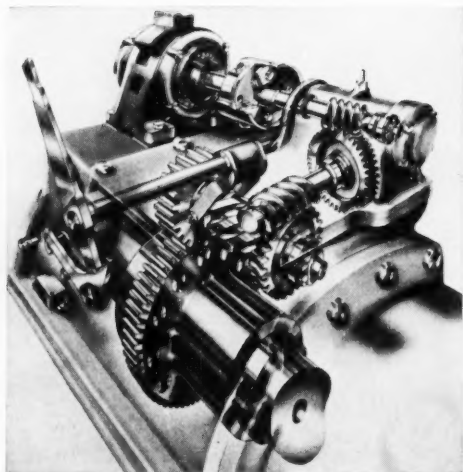
In all large units pressure lubricating systems are provided to assure an adequate and uninterrupted supply of oil to the bearings. Auxiliary pumping systems are employed to insure that the oil pressure is achieved and maintained during starting and stopping operations. Figure 13 illustrates a motor-driven turning gear which is used to rotate the turbine shaft at slow speed when the unit is cooling down after the steam supply has been discontinued. This procedure allows the unit to expand and contract evenly and avoids undue stresses that would distort and bow the shafts.

While the many types of steam turbines such as impulse and reaction, condensing and noncondensing, tandem compound and cross compound are of particular importance to the design engineer they are of little concern to the lubricating specialist since all types place similar demands on the lubricant. The method used to drive the generator is of greater interest. In the direct drive units the



*Courtesy of Westinghouse Electric Corp.*

Figure 12 — End view of tilting-pad radial journal bearing showing four longitudinal rocker pins which permit slight movement of the pads to facilitate formation of four wedge-shaped oil films.



Courtesy of Metropolitan-Vickers Electrical Company, Ltd.  
Figure 13 — Motor-driven turning gear for large steam turbine. Note engagement lever with safety locks.

turbine is coupled directly to the generator while in geared units the turbine power is transmitted through reduction gears to the generator.

For the modern high-speed steam turbine directly connected to an electric generator in stationary service as illustrated in Figure 14, it is considered desirable to hold the temperature of the oil discharged from the bearing in the neighborhood of 145°F, or at least within the range of 130°F to 160°F and the latter is rarely exceeded. The temperature and the resulting oil viscosity is controlled by the rate of oil flowing through the bearing and by the oil cooler outlet temperature which should be held within a temperature range of 110°F to

130°F. Figure 15 shows a segmented thrust and plain journal bearing in a steam turbine.

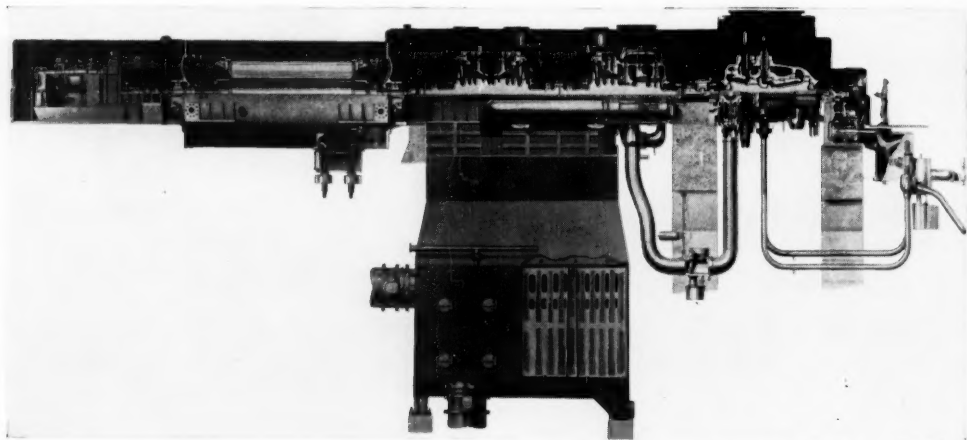
The accepted viscosity range of the oil for this type of unit is from 140 to 250 SUS (Saybolt Universal Seconds) at 100°F. This range is frequently covered with just two oils, one having a viscosity range of 140 to 170, the other 190 to 250 SUS at 100°F. The majority of turbines use the lower range viscosity product.

In auxiliary turbines and generators equipped with ring oiled bearings which are not water cooled, higher operating temperatures can be expected. This may be the result of the smaller volume of oil involved or the subjection of the bearing to large amounts of radiant heat. In any event the use of a higher viscosity oil usually in the range 250 to 350 seconds Saybolt Universal at 100°F, compensates for the increased operating temperature. However, in special applications, where loads are severe and excessive heating occurs, oils ranging in viscosity from 600 to 1700 SUS at 100°F have been used in ring oiled bearings.

Some turbines and especially the gas type, operate at such speeds that a gear reduction unit between them and their generator like that shown in Figure 16 is required.

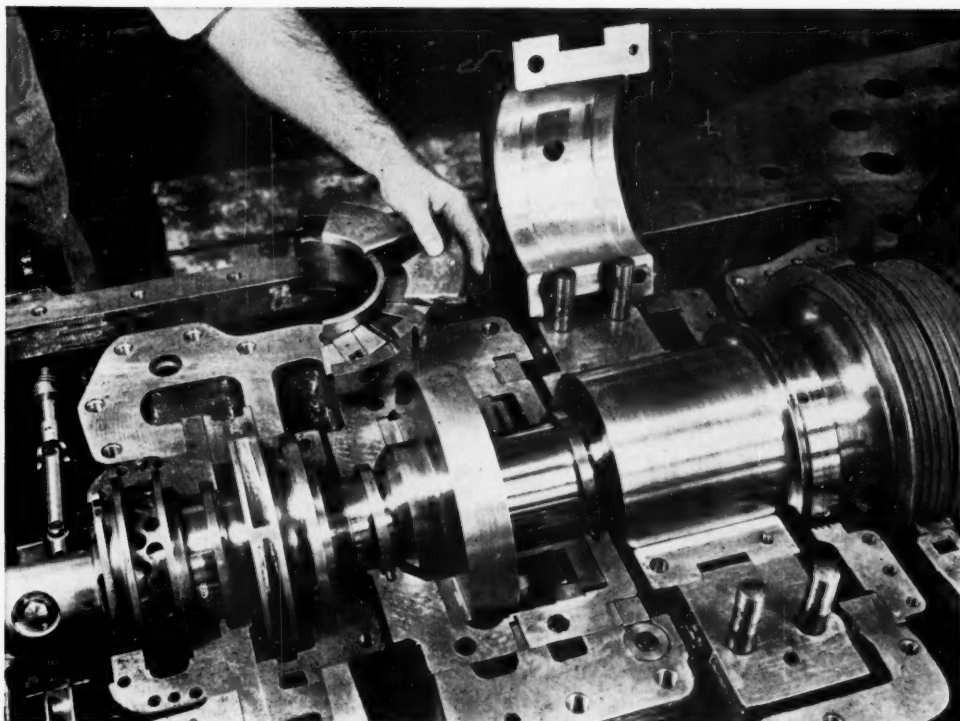
In most installations the bearing temperatures of geared units are maintained in approximately the same operating range as the directly connected units, however, a higher viscosity oil is necessary to compensate for the loads encountered in the reduction gears. The entire system — turbine, reduction gears and generator — is lubricated with an oil having viscosity between 250 and 350 SUS at 100°F.

In hydro-electric plants the design engineer is again concerned with many factors that are not



Courtesy of Allis-Chalmers Mfg. Co.  
Figure 14 — 250 megawatt direct-connected steam turbine generator unit with condenser.

## LUBRICATION



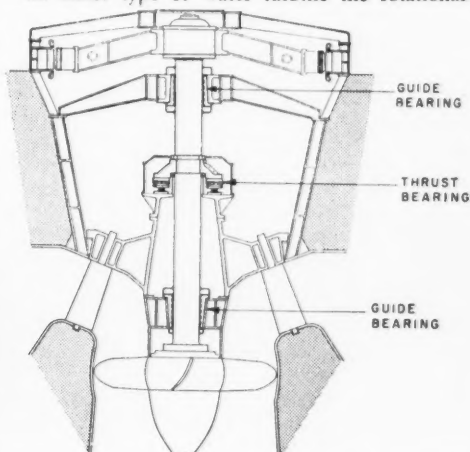
*Courtesy of Westinghouse Electric Corp.*

Figure 15 — Thrust and journal bearing in a steam turbine.

of predominant importance to the lubrication specialist. Figure 17 illustrates a large vertical-shaft hydro generating unit of the reaction type. In general the volume and pressure head of the water available determines the type of hydraulic turbine used. While it is impossible to establish a clear distinction in the fields of application between the impulse and reaction type of turbines, generally impulse turbines of the "Pelton" type like that shown in Figure 18 are adopted for high pressures while the reaction type runners illustrated in Fig-

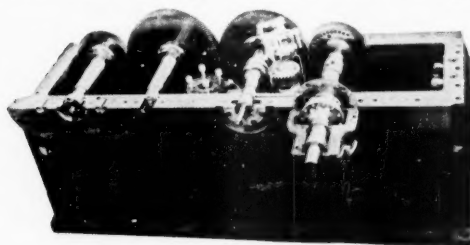
ures 17 and 19 are used with low and medium pressures.

In either type of water turbine the rotational



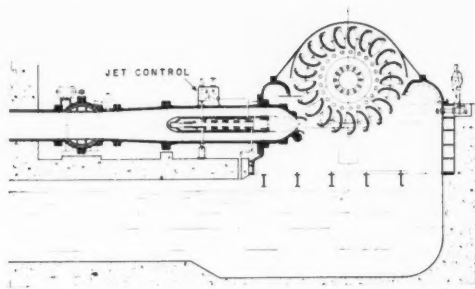
*Courtesy of Siemens-Schuckertwerke*

Figure 17 — Vertical shaft reaction type hydraulic turbine and generator.



*Courtesy of General Electric Co.*

Figure 16 — Gas turbine reduction gear unit for generator drive.



*Courtesy of Costruzioni Meccaniche Riva*

Figure 18 — Impulse type "Pelton" water wheel and water jet.

speeds are considerably lower than those encountered in steam and gas turbine power plants, however, bearing temperatures and oil viscosity remain one of the primary considerations.

In large vertical machines the thrust bearing supports all of the weight of the rotating portion of the unit, while the one or two guide bearings serve to keep the unit properly aligned in a radial direction. The principal elements of the thrust bearing are the rotating runner and a series of stationary shoes like those shown in Figure 20 which receive the load. Each shoe is free to tilt slightly in any direction which allows the formation of wedge-shaped oil films between the bearing surfaces as the thrust runner rotates. To assure an oil film between the rubbing surfaces and reduce the breakaway torque when starting heavy machines, an accessory high pressure oil system like that diagrammed in Figure 8 is frequently used. The pump which supplies oil at approximately 1000 psi to each shoe, is stopped automatically when the machine accelerates to a prescribed speed and starts automatically when the machine is being shut down. When the unit is operating at its rated speed oil is supplied to the thrust and guide bearings by either a gravity or low pressure feed from either an individual or central lubricating system. Provisions for cooling the oil are frequently made in the higher speed machines.

For large vertical machines the oil bath temperature is usually maintained in the range of 120°F to 150°F and the maximum safe operating bearing temperature is considered to be 185°F. Oils in the viscosity range of 250-350 SUS at 100°F meet the lubricating requirements of the large vertical machines.

In instances where the bearing loads are not as severe, such as in smaller vertical machines or in horizontal units, oils having a viscosity in the range of 140 to 170 SUS at a 100°F are usually acceptable.

The designers of gas turbines have also placed restrictions on oil and bearing temperatures. An operating bearing inlet oil temperature range of

110 to 130°F is recommended and a 60°F bearing temperature rise permitted, with the result that an oil of 140 to 170 SUS at 100°F is preferred. Again higher viscosity oils are used in some geared units. They range in viscosity at 100°F from 380 to 550 SUS.

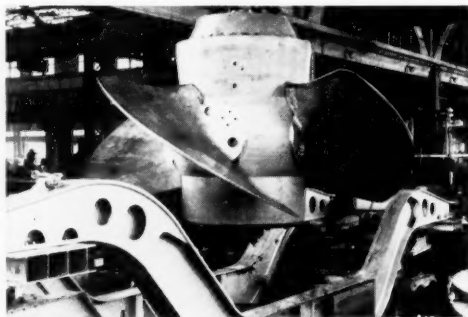
### Stability and Oxidation Resistance

When lubricating oils react with oxygen, materials are formed that impair the qualities of the oil. Eventually they become insoluble in the oil, form sludges, especially with water and foreign suspended matter, and promote the formation of deposits. On continued oxidation the oil will develop organic acids and in severe cases the viscosity will increase significantly.

The reaction between oil and oxygen is accelerated by increasing the temperature, by metallic catalysts, by water, by foreign suspended matter and by the oxidation products themselves. An increase of 18°F in the temperature of the oil will approximately double the rate of oxidation. Therefore, and aside from the viscosity considerations, an increase in operating temperatures may significantly shorten the useful life of the lubricant.

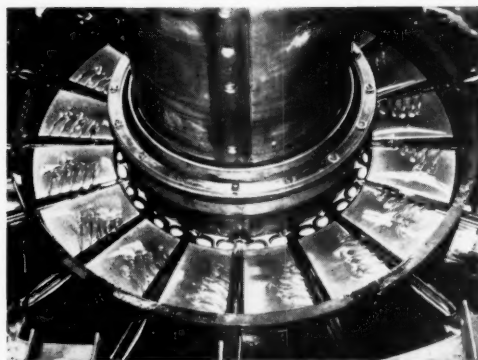
Oxidation is promoted by metals that act as catalysts. Copper, brass, bronze and zinc are particularly effective catalysts and their use is avoided as far as possible. Galvanized (zinc coated) iron piping or tanks are not recommended. The adverse effects of copper are overcome by tinning the surfaces that come in contact with the oil.

Moisture may enter the lubricating system through leaks at the sealing glands of steam turbines or at the oil coolers and through condensation from the atmosphere in the sump tank. The lubricating oil should be inspected periodically for the presence of water and if detected the source should be determined and the difficulty eliminated as soon as possible. Vapor extractors on sump tanks have been found very helpful in reducing condensation of moisture in the sump. Water leaking into the sys-



*Courtesy of Ste. des Forges et Ateliers du Creusot*

Figure 19 — Reaction type "Kaplan" turbine runner for hydroelectric unit being loaded on trailer. Note variable-pitch turbine blading.



Courtesy of Siemens-Schuckertwerke

**Figure 20 — Lower portion of thrust bearing showing oil supply to segments.**

tem from a defective oil cooler or through the labyrinth steam gland should not be allowed to accumulate; on the contrary steps should be taken immediately to remove it by extending operation of the centrifugal purifier. Centrifuging will also remove dirt, dust and other foreign material.

The adverse effects of oil oxidation are combatted by the use of oxidation inhibitors usually incorporated in turbine oils by the refiner. Even under severe operating conditions very small amounts of these materials greatly prolong the useful life of the oil.

The modern inhibited turbine oil does not deteriorate during extended storage periods. Accelerated tests as well as tests on products stored under a variety of conditions for several years have shown that the products marketed are stable during storage with no serious impairment in any of the desirable properties.

## Rust and Corrosion Prevention

The importance of the lubricant's ability to prevent rusting and corrosion cannot be over-emphasized since this characteristic is essential to assure long and dependable equipment service. In all three types of units, there always is the possibility of water contamination. The detrimental effects of rusting of iron or steel rubbing surfaces are quite obvious: even worse, however, are rust or iron oxide particles in the hydraulic systems of the governor controls which render the controls ineffective, damage the equipment and result in costly down time for cleaning and repairs. Rust particles in the main lubricating system can also imbed in and seriously damage main bearing surfaces.

While oil filters and oil purification systems are employed to remove foreign material from the lubricant, the most effective method of preventing damage from rusting and corrosion is the use of a properly inhibited oil. Since straight mineral oils

may be displaced by water from metal surfaces, they do not always protect against rusting. As a result, additives have been developed for turbine oils which give increased protection against rusting and do not detract from the other desirable properties of the lubricant. These additives are "polar" materials that concentrate at the points of contact between oil and ferrous metal when water is present. As a result of their successful use, rusting has become a very minor problem.

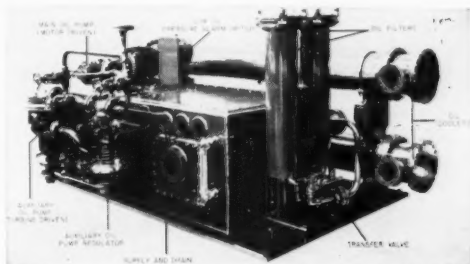
Corrosion or chemical attack of lubricating systems by the oil is another problem that is very seldom encountered since the development of the modern inhibited turbine oil. If a lubricating oil has been retained in service for periods long enough for excessive oil oxidation to occur, the oil oxidation products may become corrosive to certain high lead babbitt bearings and, in addition, promote the formation of sludge and deposits. However, by laboratory inspections of periodic samples of oil taken from lubricating systems, the degree of oxidation may be determined and the system oil changed before it becomes excessively oxidized. The neutralization number test is used to measure the degree of oxidation since it gives an indication of the amount of oil oxidation products present. A neutralization value of 0.50 is typical of the limit chosen by some users to indicate when a used inhibited oil should be replaced.

### Foam Resistance

The formation of foam on the surface of the oil in the sump tank indicates the presence of air in the oil. It is essential that most of the air entrained in the oil while flowing through the lubrication system be eliminated before the oil is recirculated. Entrapped air reduces the flow of oil to the bearings and causes erratic operation of the governors. Turbine oils are manufactured so they free themselves of air very rapidly. In general, low viscosity oils dissipate entrained air more rapidly than oils of higher viscosity.

Air entrainment is promoted by the following mechanical and operation conditions:

1. Air leakage into the suction line.



*Courtesy of Westinghouse Electric Corp.*

Figure 21 — Oil supply unit.



2. Low oil level, permitting the pump suction inlet to become exposed to air.
3. Insufficient venting of the lubricating system.
4. Excessive splashing from oil return lines to the sump oil level.
5. Oil return lines of insufficient size or capacity.
6. Discharge velocity from pressure regulating valve too high resulting in unnecessary splashing and spray above the oil level.
7. Operating the circulating oil pump at excessive capacity.
8. Wide difference in temperature between fresh oil added and the oil in the system.
9. Vacuum conditions inside bearings.

All of the above conditions are easily corrected by obvious mechanical changes and adjustments.

When hydrogen cooled generators are employed, the ability of the oil to free itself from entrained gas takes on added importance. The system oil is used to provide an oil film between the continuous babbitt seal face and the shaft flange to prevent the escape of the cooling hydrogen. Since the oil is supplied under a pressure greater than the hydrogen pressure, provisions must be made for the oil flowing through the seal to be returned to a hydrogen detaining tank where the oil and hydrogen are separated.

### OIL MAINTENANCE

In the three types of electrical power generating equipment discussed, a single oil, usually from a central supply, is used to lubricate the main bearings of turbine and generator, the governor and other auxiliary equipment, as well as serve as a hydraulic fluid in the control systems. For the lubricant to perform all these functions successfully for long periods of continuous operation it must be maintained in clean condition. To guarantee satisfactory performance, all of the lubricating systems are provided with equipment that removes water sludge and foreign material from the oil. Figure 21 illustrates a typical oil supply unit of the filtration type.

Clarification by allowing the contaminants to settle in a special tank is the simplest method, however, this is time consuming, requires extra tankage and the use of two complete batches of oil.

Centrifuging involves the same basic principles as settling, but is faster since the separating force is increased several thousand times. By continuous operation of the centrifuge the complete batch of lubricant can be clarified without shutting down the unit for changeover. This method will remove oil insoluble materials such as water and dirt but it cannot remove oil soluble impurities. Water washing plus centrifuging have been used to remove soluble impurities from uninhibited oils. However, industry feels this procedure should not be recommended for rust and oxidation inhibited oils since it may cause a reduction in the inhibitor level.

Many varieties of filters are also employed to remove suspended materials from the oil. However, if an inhibited oil is in use, the filtering material should be chosen with care since some types will remove all or part of the inhibitors. Filters with inert packings are widely and successfully used on either inhibited or straight mineral oils.

### Cleaning Lubricating Systems

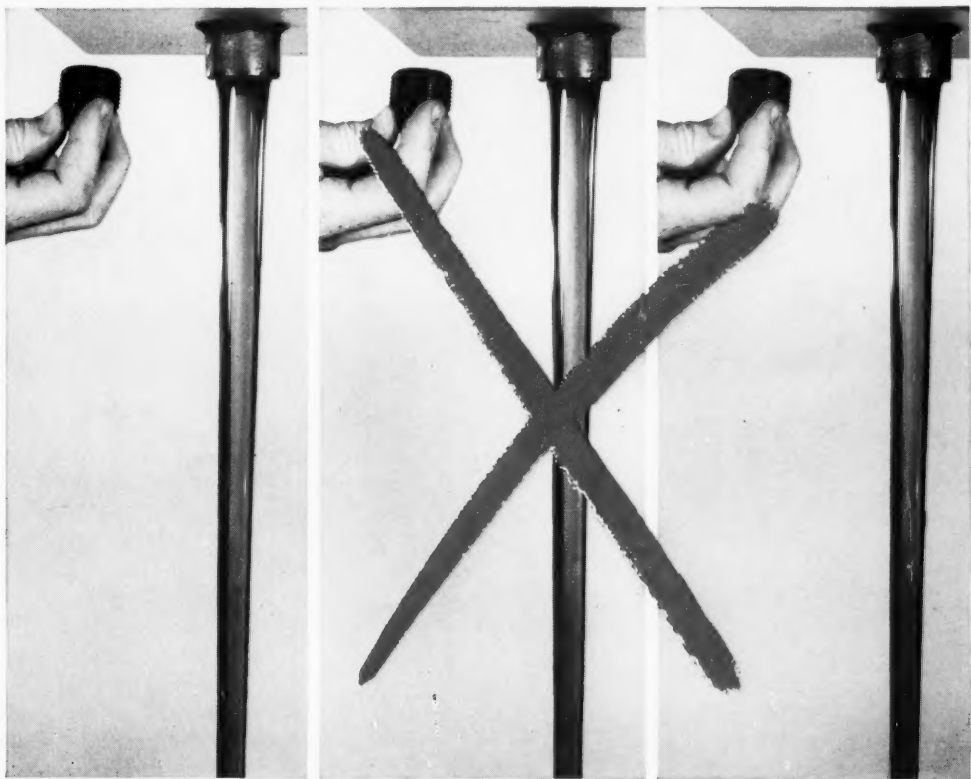
In new units that are being installed or in units that have been taken down for scheduled inspections special precautions are necessary to assure that the lubricant is not contaminated with foreign material. Manufacturers and a joint ASTM-ASME Committee on Turbine Lubrication have recommended procedures that should be followed. Essentially the entire lubricating system must be thoroughly clean. All foreign material incident to erection or cleaning must be removed. The system is then flushed by circulating inhibited flushing oil heated to at least operating temperatures. After flushing it may be desirable to follow with a displacement oil of the same type to be used later for lubrication. If after inspection, the system is in satisfactory condition, the lubricating oil is installed.

### SUMMARY

In most instances the source of energy used to generate electricity where turbines are used as prime movers does not materially change the lubrication requirements. Steam, water and gas turbines place similar demands on the lubricant.

The advances in generating equipment design have been paralleled by the development of modern inhibited oils which provide lower maintenance requirements with longer and more reliable operation.





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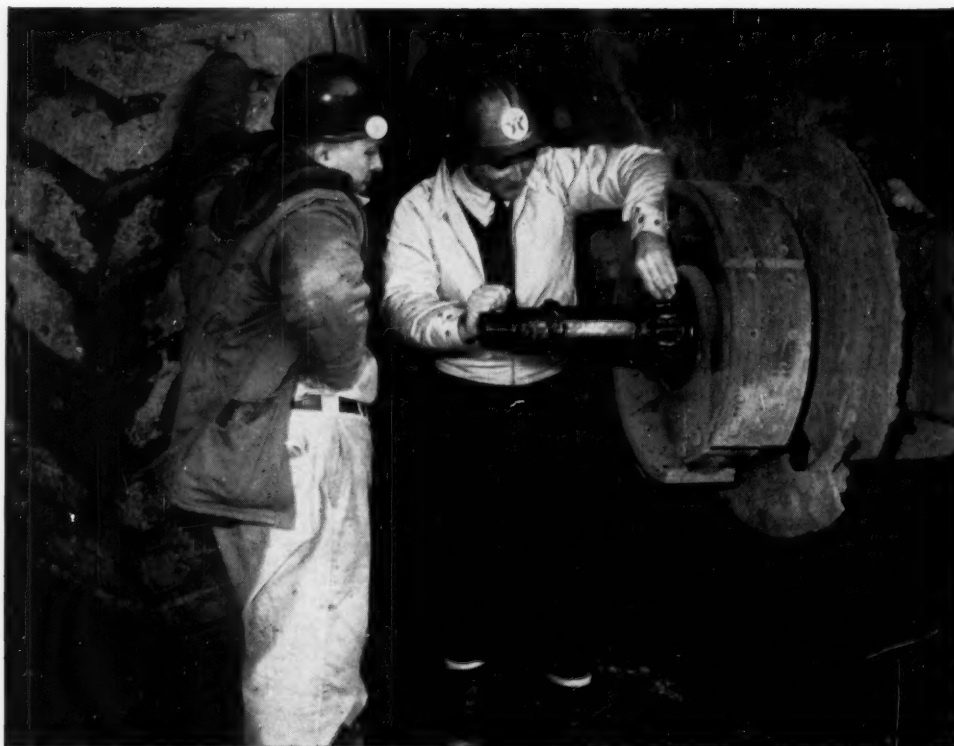
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